4 Streamlined Risk Evaluation

Oil shale mining activities from the APF have probably influenced the surrounding environment since the creation of NOSR #1 in 1916. Processed shale generated from mining activities has contributed inorganic elements into the waste shale pile and impoundments; inorganic and organic (attributed to *in-situ* combustion within the waste shale pile) elements in the ground water; and the surface water through leaching of waste materials. The area is used year-round for oil and gas exploration and production. Hunting and cattle grazing also occur on the property.

4.1 Chemicals of Concern

The chemicals of concern (COCs) and migration pathways were identified from historical information and a detailed site evaluation. The COCs selection process utilized chemicals that have been observed in the spent shale pile and impoundments at the site.

- Human and ecological COCs for the waste shale and impoundments at the Site are: aluminum, arsenic, boron, barium, chromium, cobalt, copper, iron, lithium, magnesium, manganese, molybdenum, sodium, nickel, lead, vanadium, and zinc. The primary chemical driver at the site for the waste shale pile is arsenic, as it remains the only inorganic in the waste shale pile that exceeds constituent specific residential (unrestrictive) risk based standards (CDPHE 2000).

- Human and ecological COCs for ground water at the Site are: iron, manganese, and sulfate (as concluded by CDPHE as a result of leaching from the spent shale pile into ground water) and are present in ground water at concentrations exceeding Colorado Primary or Secondary Ground Water Standards.

- The human and ecological COCs for surface water at the site is iron, as it is the only inorganic element that appears to be leaching at a concentration exceeding Colorado Water Quality Standards (CDPHE 2000). However, seeps into the

gulch from the waste shale pile contained elevated concentrations of iron, manganese, and sulfate.

- Although inhalation is a potential pathway of exposure, there are no human and ecological COCs for air currently at the site.

4.2 Potential Receptors

Potential receptors, receptor exposure routes, and exposure scenarios were identified from on-site visits and discussions with BLM personnel. Representative wildlife receptors at risk were chosen using a number of criteria, including likelihood of inhabitation, and availability of data. CDPHE concluded that the concentrations of inorganic elements in the shale pile were not significantly variable at different horizontal locations across the pile. Figure 4-1 presents the site conceptual exposure model (SCEM) for exposure to mining waste at the site and identifies the potential exposure pathways to off-site residents, on-site workers/visitors, and wildlife.

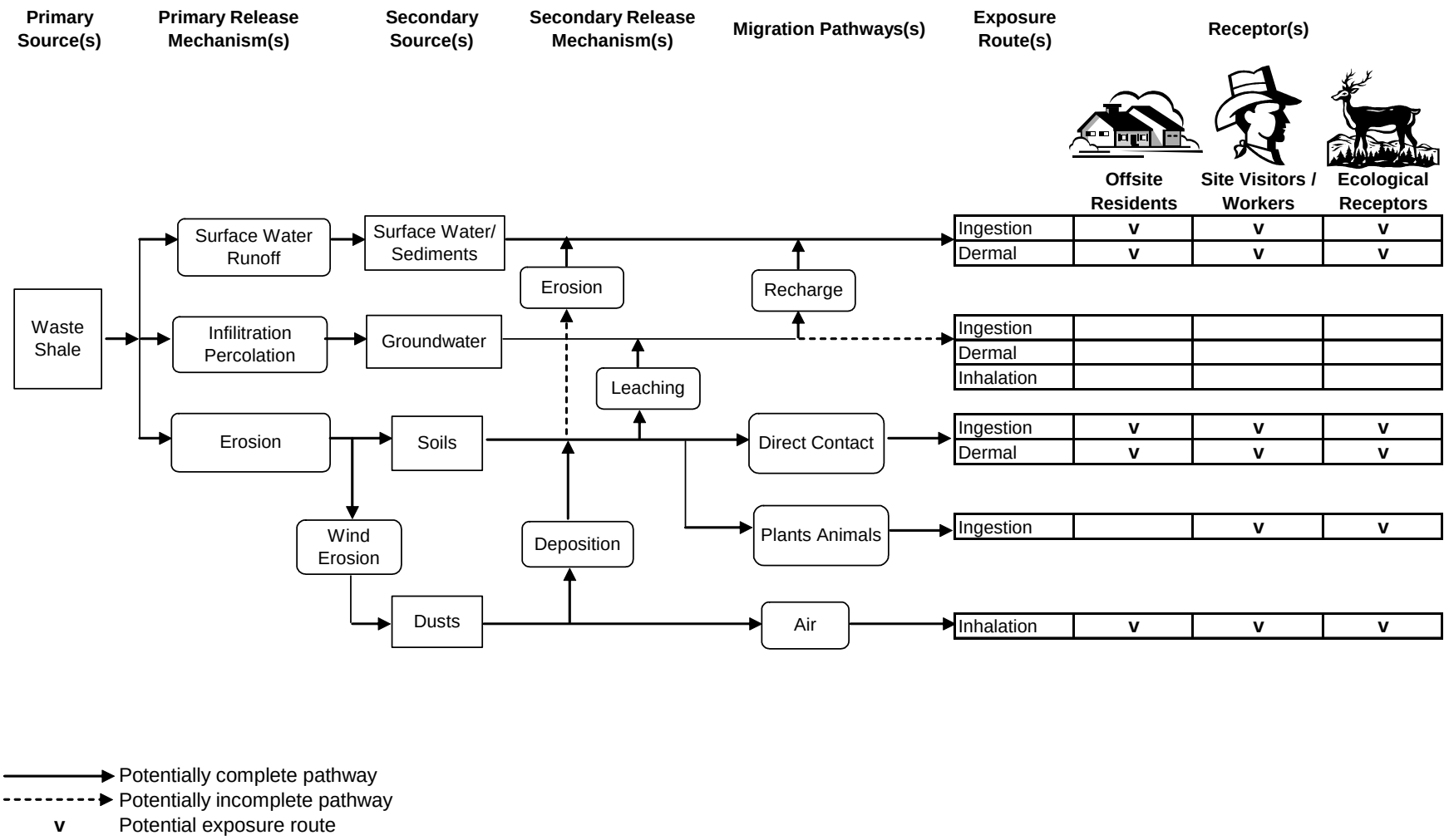
Workers present within 4 miles of the site include Cimarron Oil and Gas Processing Equipment, Inc., currently occupying the former Paraho Development building (located approximately ½ mile from the waste shale pile, and 2,000 feet from the closest edge of the former Plant Site). Three to four workers are present in this building on a regular basis. The Garfield County Landfill (located approximately ¾ of a mile east of the former Town Site) has 14 people (employees and work crews) present on a regular basis. The Williams Energy water evaporation facility south of the APF (about ½ mile south of the Town Site) and the Rulison Compressor Station do not have workers present on a continual basis. As described above, oilfield workers also are present throughout the area to service the wells and associated facilities.

A representative of Nabors Drilling mentioned that Williams Energy is planning on having four drilling rigs continuously drilling wells in Sharrard Park within the next year, which will employ about 40 people during the year (personal communication with Alan Kraus, 2004). Several businesses are located 2.7 to 3.0 miles southeast of the Plant Site, along the railroad line. These include a pipe yard occupied by Colorado Tubulars/Aztex Pipe, a construction materials yard (with no sign), and a cement bulk loading facility (operated by Holcim, a multinational cement and aggregate supplier). These facilities appear to be occupied sporadically, with the possible exception of the Holcim loading facility.

The nearest building with consistent occupation is the former Paraho Development building, currently occupied by Cimarron Oil and Gas Processing Equipment, Inc. This building is located about ½ mile from the waste shale pile.

The major potential impact to sensitive plant species from the repository would be from windblown dust generated during construction activities. This would be temporary, and dust control measures will be employed. Regarding potential uptake by plants on the.

Figure 4-1: Mine Waste Site Conceptual Exposure Model (SCEM) for Human and Ecological Receptors



repository itself, a 3-foot-thick cap is proposed for the repository. The cap will be revegetated. Given the arid climate, the vast majority of moisture consumed by plants will be from the upper three feet of their root system. Hence, even if their roots penetrate the shale material, very little contamination is likely to be absorbed by the plants

4.3 Human Health Risk Assessment

There are two types of risk associated with the APF: off-site risk and on-site risk. Off-site risk is associated with releases of spent shale into West Sharrard Creek and into the air through wind erosion. Due to the instability of the pile, a major flood event could cause the pile to collapse into the gulch, resulting in a catastrophic release of contaminated sediments downstream of the site and ultimately to the Colorado River. While this is a low probability event, it is an event of serious concern to BLM and has been identified as an unacceptable risk by the CDPHE.

There are several potential air pathway concerns at the APF. The primary one is the potential for contaminated dust emanating from the shale pile to be ingested by visitors to the site. Such exposures might happen to individuals who use BLM lands for oil and gas exploration and production activities and/or individuals who work on BLM lands as well as hunters and other recreational users. Contamination may migrate from the BLM tracts to adjoining property.

According to CDPHE, arsenic appears to be present at a level that would pose a risk to human health and the environment, with an approximate concentration in the waste shale pile of 37 mg/kg. CDPHE performed health based risk calculations under a residential exposure setting using the concentration of arsenic in the waste, the assumptions and rational outlined in the CDPHE Guidance on Risk Assessment, and health based toxicity data obtained from the Integrated Risk Information System (IRIS).

With regard to human health risk from the waste shale pile, the BLM's position is that the concentration of arsenic in background soil has not been fully characterized and such characterization may better define the risk from arsenic that the waste shale poses compared to native soils. It should also be noted that sampling and analysis conducted subsequent to the CDPHE report measured arsenic concentrations averaging 74.0 mg/kg. However, BLM has adopted a precautionary approach to the potential for human health risk from the waste shale and will use the CDPHE's conclusions as a basis for evaluating a removal action. These conclusions are presented below.

4.3.1 Carcinogenic Risk for Shale Pile

According to the CDPHE 2000 Report:

> "*The calculated carcinogenic risk posed by the concentration of arsenic in the waste indicates that when evaluated under a direct exposure residential setting, the waste pile poses a significant carcinogenic health risk. Normally, if a waste or soil*

contains a constituent, which exceeds a calculated carcinogenic risk of 1 x 10^{-6} (or 1 cancer death per million exposed individuals), the waste is deemed to possess an unacceptable risk to human health. The amount of carcinogenic risk posed by the concentration of arsenic in the waste shale pile is 1.6 x 10^{-4} evaluated under a residential setting and 5 x 10^{-5} evaluated under an industrial setting. The amount of carcinogenic risk posed by the concentration of arsenic in background soil in the areas is 2 x 10^{-5} evaluated under a residential setting and 5 x 10^{-6} evaluated under an industrial setting."

4.3.2 Non-Carcinogenic Risk for Shale Pile

According to the CDPHE 2000 Report:

"Non-carcinogenic risk effects are expressed as a ratio of the contaminant intake in one pathway to the RfD for that pathway. This ratio is called the Hazard Quotient (HQ). If the HQ for a particular constituent in the waste, or the accumulative HQs for all the constituents in the waste and all the pathways for exposure exceed 1.0, the waste is deemed to possess an unacceptable risk to human health. The calculated non-carcinogenic risk or hazard quotient posed by the concentrations of arsenic in the waste shale pile indicates that when evaluated under a direct residential exposure scenario, the waste pile poses a significant non-carcinogenic health risk. The estimated HQ for the arsenic in the waste pile is 2.4. The predicted acceptable residential non-carcinogenic soil clean up level for arsenic is 23 ppm as listed in the EPA Region 7, Risk-Based Concentration Table, July-December 1995. Site background soil possesses a non-carcinogenic health risk hazard quotient of 0.33 evaluated under a residential setting."

4.3.3 Health Effects

According to the CDPHE 2000 Report:

"Arsenic is a known human carcinogen (Class A carcinogen). Studies have linked Arsenic exposures to significant rates of excess lung cancer cases due to inhalation exposures, as well as to elevated rates of skin, bladder, liver, kidney, and colon cancer from ingestion of arsenic contaminated drinking water. Non-carcinogenic effects of arsenic exposure include skin lesions and abnormal nerve conduction (IRIS, 1995)."

4.4 Ecological Risk Assessment

Wildlife in the APF may be exposed to metal contamination via several environmental pathways as shown on the SCEM. The potential exposure pathways include soil and sediment ingestion, vegetation ingestion, surface water ingestion, inhalation of airborne dust, and dermal contact with soil, sediment, and surface water.

As stated in the site characterization section of this report, much of the APF site lies within lands mapped by the CDOW as big-game winter range and portions of lands along the southern edge of the APF site are denoted as big-game winter concentration areas, with some additional lands mapped as winter seclusion areas. Large to midsize predators including: black bears, mountain lions, bobcats, coyotes, red foxes, American badgers, long-tailed weasels, short-tailed weasels, and minks are found at the site along with small mammals that include: white-tailed jackrabbits, desert cottontails, beavers, muskrats, porcupines, several members of the squirrel family, various species of mice, bushy-tailed woodrats, and white-tailed prairie dogs. Bat species, including BLM sensitive species, are present at the site, as are raptor species. Reptiles at the site include a number of lizards and snakes, including two snake species listed as sensitive. Amphibian species in the area include the tiger salamander; the Great Basin spadefoot and northern leopard frog (both BLM sensitive species); and Woodhouse's toad.

As the waste shale at the site possesses an unacceptable risk to human health, all removal action objectives and scope will be directed toward abating this risk and preventing exposure to receptors. It is anticipated that all actions directed toward reducing the human health risk will sufficiently address any concerns regarding ecological risk at the site; therefore, a full ecological risk assessment has not been performed for the site.

4.5 Risk Assessment Results

Tables 4-1, 4-2, and 4-3 compare the maximum media concentrations at the site with the selected appropriate risk-concentration values. The ratio of the environmental media concentration to the risk-concentration value is analogous to a HQ of 1.0; the concentration that should present negligible risk.

While several metals of concern are present at concentrations exceeding three times background in soil, three metals exceed established soil screening levels. Arsenic concentrations in waste shale and native material beneath the waste shale significantly exceed the Colorado soil clean-up guidelines for residential or unrestricted land-use, and the EPA risk-based concentrations for both industrial and residential sites. Beryllium concentrations in waste shale and native material beneath the waste shale exceed the EPA risk-based concentration for residential sites, but not the risk-based concentration for industrial sites. Based on the results of the 2000 CDPHE study, iron concentrations in waste shale exceed the EPA risk-based concentrations for residential sites. However, iron concentrations obtained by Dynamac (1998) and E&E (2004) are less than the risk-based criterion (RBC).

Aluminum, arsenic, boron, cadmium, chromium, iron, lead, manganese, nickel, and vanadium exceed one or more risk based ground water guidelines for human health, agricultural use, or tap water (CDPHE 2000). No metals of concern exceed established Colorado surface water risk based guidelines; however, potassium and sodium are found at concentrations three times background.

Table 4-1: Summary of Maximum Soil/Shale Concentrations, mg/kg									
Inorganic Analyte	Dynamac 1998	CDPHE 2000	E&E 2003 Waste Shale Pile	E&E 2003 Impoundments	Background[1]	CO Soil Cleanup Res. / Unrest. Use	CO Soil Cleanup Prot. Of Ground-water	RBCs Ind.[2]	RBCs Res.[2]
Aluminum	15,000	NA	19,500	21,900	6,300	None	None	1E+06	78,000
Antimony	ND	0.8	ND	ND	ND	None	None	820	31
Arsenic	47	37	74.0	51.1	5.7	0.21	None	3.8	0.43
Barium	360	494	568	419 B	120	None	None	140,000	5,500
Beryllium	0.9	1.0	1.26	1.17	ND	None	None	1.3	0.15
Boron	NA	95	NA	NA	0.35	None	None	180,000	7,000
Cadmium	ND	ND	0.375 J	0.366 JB	0.5	99.5	None	1,000	39
Calcium	100,000	NA	119,000	109,000	35,000	None	None	None	None
Chromium	26	32.5	33.5	33.9	6.8	53.94	None	10,000	390
Cobalt	8.6	9.0	11.7	9.96	5.1	None	None	120,000	4,700
Copper	41	41	199.0	52.7	12	2,570	None	82,000	3,100
Iron	17,000	24,000	22,700	22,800	12,000	None	None	610,000	23,000
Lead	23	26.5	42.2	27.4	11	400	None	*	*
Magnesium	35,000	40,800	43,200 B	39,400 B	6,300	None	None	None	None
Manganese	310	500	387 B	396 B	280	None	None	47,000	1,800
Mercury	ND	0.1	0.0562	0.358	ND	17.66	None	610	23
Molybdenum	NA	13	NA	NA	ND	None	None	None	None
Nickel	21	22.5	28.9	22.1	12	None	None	41,000	1,600
Potassium	6,700	NA	11,400	4,980	1,500	None	None	None	None
Selenium	7.8	0.1	4.88	4.54	3.7	None	None	10,000	390
Silver	ND	ND	0.494 J	0.537 J	ND	None	None	10,000	390
Sodium	8,500	9,100	23,400	8,730	770	None	None	None	None
Thallium	1.1	0.6	ND	ND	ND	None	None	140	5.5
Vanadium	88	108	113	87.7	21	None	None	14,000	550
Zinc	61	91	84.8	104	47	None	None	610,000	3900
	= Exceeds Risk Based Criteria								

1. From Dynamac 1998 and CDPHE 2000.
2. Ingestion Risk-Based Concentrations (mg/kg) of Inorganic Chemicals of Potential Concern in Soils, from EPA Region III Risk-Based Concentrations, R.L. Smith (04/18/1996).

* No RBC is listed by EPA Region III

CDPHE = Colorado Department of Public Health and Environment
CO = Colorado
E&E = Ecology & Environment, LLC
NA = Not analyzed
ND = Not detected
Ind. = Industrial
Res. = Residential
Unrest. = Unrestrictive
Prot. = Protective

Table 4-2: Summary of Maximum Ground Water Concentrations, mg/L						
Inorganic Analyte	Dynamac 1998	CDPHE 2000	Background[1]	CO GW Human Health (CDPHE 1999)	CO GW Agri.	RBCs Tap Water[2]
Aluminum	81	NA	28	-	5	37
Arsenic	0.044	0.099	0.004	0.050	0.100	4.5E-05
Boron	NA	0.84	0.35	-	0.00075	3.3
Barium	0.49	0.48	0.24	2.0	-	2.6
Beryllium	0.0056	0.0018	ND	-	0.100	0.073
Cadmium	0.0089	0.006	ND	0.005	0.010	0.018
Calcium	460	NA	300	-	-	-
Chromium	0.13	0.0062	0.026	0.100	0.100	0.11
Cobalt	0.044	0.05	0.0098		0.050	0.73
Copper	0.094	0.071	0.018	1.0	0.200	1.5
Iron	76	54	19	0.300	5.0	11
Lead	0.056	0.09	0.022	0.050	0.100	-
Magnesium	430	NA	180	-	-	-
Manganese	2.7	5.94	0.34	0.050	0.200	0.73
Mercury	ND	0.00032	ND	0.002	-	-
Molybdenum	NA	0.14	ND	-	-	0.18
Nickel	0.11	0.068	0.019	0.100	0.200	0.73
Potassium	190	NA	29	-	-	-
Selenium	0.044	0.032	ND	0.050	0.020	0.18
Silver	ND	0.00025	ND	-	-	0.18
Sodium	1,100	768	370	-	-	-
Thallium	ND	ND	ND	0.002	-	0.0026
Vanadium	0.21	0.088	0.071	-	0.100	0.011
Zinc	0.38	0.27	0.12	-	2.0	11
	= Exceeds Risk Based Criteria					

1. From Dynamac 1998 and CDPHE 2000.
2. EPA Region III RBC Table 10/15/2003. No value is listed.

Agri. = Agricultural
CDPHE = Colorado Department of Public Health and Environment
CO = Colorado
GW = Ground water
NA = Not analyzed
NDNot detected

Table 4-3: Summary of Surface Water Concentrations[1], mg/L

Inorganic Analyte	Dynamac 1998	CDPHE 2000	E&E, 2004	Back-ground[2]	CO SW Water – Drinking Water Supply (CDPHE 2001(a))	CO SW Water – Fish (CDPHE 2001(a))	CO SW Aquatic Life - Acute (CDPHE 2001(a))	CO SW Aquatic Life – Chronic (CDPHE 2001(a))
Aluminum	0.11	NA	ND	0.047	-	-	-	0.087
Antimony	ND	ND	ND	ND	0.006	0.006	-	-
Arsenic	ND	0.002	0.0137 J	ND	0.050	0.000018	0.34	0.150
Boron	NA	0.33	NA	NA	-	-	-	-
Barium	0.04	ND	0.0371	0.036	1.000	-	-	-
Beryllium	ND	ND	ND	ND	0.004	-	-	-
Cadmium	0.0021	ND	ND	ND	0.005	-	0.0037	-
Calcium	170	NA	189	100	-	-	-	-
Chromium	ND	ND	ND	ND	Cr III: 0.050 Cr VI: 0.050	-	0.016	Cr III: 0.0741 Cr VI: 0.011
Cobalt	0.005	ND	ND	ND	-	-	-	-
Copper	ND	0.02	ND	ND	1.000	-	0.0134	0.00896
Iron	0.042	1.26	ND	0.024	0.300	-	-	(total recoverable) 1.000
Lead	ND	ND	ND	ND	0.050	-	0.0646	0.00252
Magnesium	130	NA	136 B	68	-	-	-	-
Manganese	0.066	0.05	0.00951 J	ND	0.050	-	2.986	1.650
Mercury	0.00005	ND	ND	ND	0.002	-	0.0014	0.00001
Molybdenum	NA	0.1	NA	NA	-	-	-	-
Nickel	ND	ND	ND	ND	0.001	-	0.014	0.052
Potassium	41	NA	8.860 B	8.3	-	-	-	-
Selenium	0.017	0.01	0.0529	0.019	0.050	-	0.0184	0.0046
Silver	ND	ND	ND	NA	0.100	-	0.00203	0.032
Sodium	1,800	215	347 B	220	-	-	-	-
Thallium	ND	ND	ND	ND	0.0005	0.0005	-	0.015
Vanadium	ND	ND	0.0166 J	ND	-	-	-	-
Zinc	0.086	0.05	0.00369 J	0.041	5.000	-	0.1172	0.1181

1. From Dynamac 1998: filtered inorganics and unfiltered organics, highest value of five samples. From CDPHE 2000: (downstream from seep).
2. From Dynamac 1998 and CDPHE 2000: Dynamac collected a background surface water sample (APF-1SW) at a location upstream of APF-OR1. CDPHE collected a surface water sample (referred to as WOR1 in CDPHE's data table, and shown as ORW-1/5894 on CDPHE's map) at a location very near, but apparently slightly upstream from APF-1SW.

CDPHE = Colorado Department of Public Health and Environment
E&E = Ecology & Environment, LLC
CO = Colorado
SW = Surface water
- = No value is listed
NA = Not analyzed
ND = Not detected

4.6 Removal Action Criteria

While several metals of concern are present at the site, arsenic concentrations in waste shale and native material beneath the waste shale significantly exceed risk-based guidelines. Furthermore, it has been shown that the waste shale pile is unstable and could result in catastrophic failure and collapse creating the potential for migration of contaminants into West Sharrard Creek. Arsenic concentrations in the waste shale therefore pose a potential threat to human health and the environment.

The proposed removal action criteria is the reduction or elimination of the threat to human health and the environment posed by ingestion, inhalation, and dermal contact with arsenic in the waste shale as well as elimination of the potential for collapse of the pile into West Sharrard Creek.